DVGW[1]

Technical Rules

W 512

September 1996

Testing procedures to evaluate the effectiveness of water conditioning devices for the reduction of scaling

1 DVGW is the German Gas and Water Co-operation

Preface

The following worksheet describes the test procedure for evaluating the effectiveness of water conditioning devices, that are installed to prevent or to reduce scaling in drinking water heating devices and in other devices.
The subject of this worksheet is not to describe the water conditioning devices, but instead to determine rules regarding the evaluation of test results.
This worksheet describes in detail the general version of the VDI-guideline 2035 sheet 1 section 7, for "tests on the effectiveness of protective measures".

To obtain the DVGW inspection sign, the proof that all requirements are met is essential, but not an adequate prerequisite. Further requirements regarding safety, hygiene and operating suitability arise from the relevant technical rules e.g. DIN 1988 "Technical rules for drinking water installation" and also legal regulations like the Lebensmittel- und Bedarfsgegenstaendegesetz.~

Bonn, September 1996
DVGW Deutscher Verein des Gas- und Wasserfaches

2 The conferring British Standard is: BS 3999-16
BS EN 60335-2-51

Contents

1. Range of Application

This worksheet applies to the area of heating drinking water and also to the storage and distribution of it. It only applies to the evaluation of devices, that are fitted in installations with regard to DIN 1988 for a lasting reduction or prevention of scaling.

2. Terms

2.1 The heating of drinking water

In this worksheet the heating of drinking water is regarded as the preparation of heated water with drinking water quality in suitable drinking water devices. This term does not include the heating of industrial waters.

2.2 Water conditioning devices

The term water conditioning devices applies to devices including technical facilities and means to prevent or reduce scaling.

2.3 Scaling

With scaling this worksheet regards the development of precipitation of scale, which develop as solid deposits around the areas of heat transmission.

2.4 Calcite Precipitation Capacity

The Calcite precipitation.capacity is the amount of calcium carbonate available in water at a certain temperature that precipitated as insoluble material. According to DIN 38 404-10 the calcite precipitation capacity can be calculated. The precipitation capacity of calcite does not represent the actual precipitated amount of scale that is difficult to dissolve.

3. Requirements

3.1 Testing Water

The tests are conducted with drinking water that has a calcite precipitation capacity (calculated for 15 ^{0} C) of at least 30 mg/l of calcium carbonate. The total hardness of the testing water has to

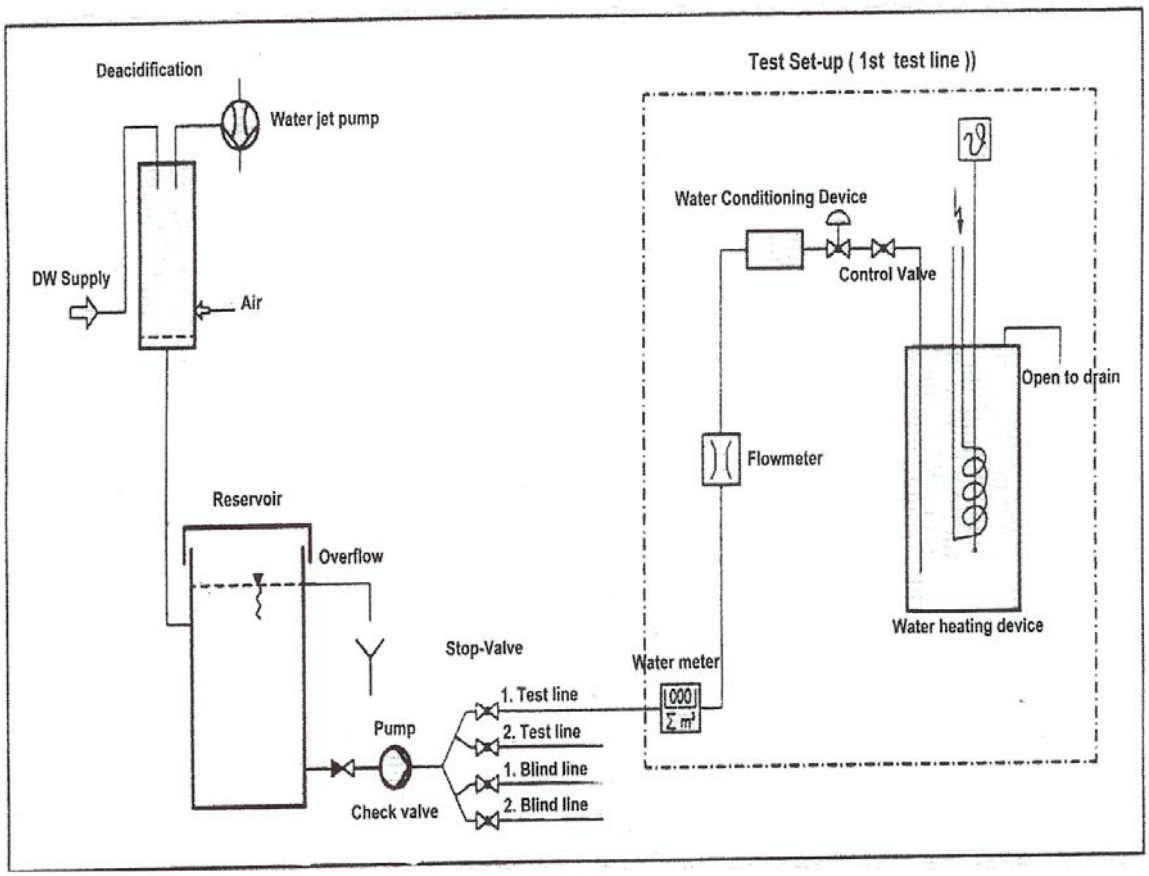
amount alkaline earth compound to at least 3.5-mol/m3-. The magnesium portion should not exceed 25% of the calcium content (20% of the overall mass). If the original water does not possess the required calcite precipitation capacity, appropriate measures of deacidification can be taken to obtain it (as shown in the figure in page 8). To determine if a suitable amount of scaling for the evaluation occurred over a period of 21 days, test trials (blind trials - see section 3.5) have to be conducted. These requirements are fulfilled if according to the testing method in section 3.4 the analytical determination of scale contains 0.1 -mol alkaline earth compound respectively 10g of calculated calcium carbonate per test trial.

3.2 Test Set-up

The schematic structure of the test is displayed in the figure on page 8.

The testing structure consists of 4 identical appliances (test lines and blind lines) for the testing of different types of water conditioning devices. The four test appliances must be operated parallel in the same way, so that two appliances operate as test lines and the other two as blind lines.

Figure 8



The supply of testing water to the drinking water heating device has to be carried out completely in chrome-nickel-steel pipes that are austenitic and contain molybdenum. A feed pump with an operating pressure of 2.5 +/- 0.3 bar (pressure reducing valve) ensures the supply of testing water (as described in 3.1), but the feed pump is only delivering test water while drawing off water from a depressurised water reservoir.

In each intake pipe of the four test appliances the supplied amount of water is measured by a water meter and a flowmeter and is adjusted by a control valve. The stop-valve (preferably compressed air controlled) has to be fitted at the supply of the drinking water heating device. Standard 10 litres drinking water heating devices, depressurised and usually electrically heated are used. Their heating elements have a surface power density of 6.5 W/cm2 maximum and they can be operated at a water temperature up to a maximum 80 °C.

To determine the temperature of the reservoir water, temperature sensors with the precision of +/2 K are additionally installed in the area of the heating coil. During the test the response to temperature changes has to be measured and registered continually. Voltage and Current or Voltage and Power have to be recorded at the same time.

The warm water outlet is open to drain. To control the amount of water that has to be withdrawn, the stop-valve at the supply of the test water is opened or closed.

3.3 **Test method**

The amount of water used in each of the test appliances has to be 130 litres per day. This amount of water has to be drawn over a period of 16 hours. The throughput (flow rate) has to be at least 5 l/min. On two occasions during the day the whole amount of water in the drinking water heating devices has to be drawn off.

In the period of 16 hours the water has to be drawn off as follows:

At 0h; 2h; 2.5h; 3.5h; 4h; 4.5h; 5h; 6h; 6.5h; 7h; 7.5h; 8h; 9h; 9.5h; 10h; l1h; 11.5h; 12.5h; 13h; 13.5h; 14h and 16h the amount of water drawn is 5 litres. At 3h and 12h the amount to be drawn is 10 litres.

After an operating phase of 16 hours an 8-hour period of rest has to be left.

The water temperature in the drinking water heating devices is 80 ^{o} C +/- 3 K. If the drinking water heating device is tested with a lower temperature (with a tolerance of +/- 3 K) according to the specifications of the manufacturer, these specifications have to be displayed in the product papers and in the manuals.

3.4 Testing Procedure

In all the tests, the test lines and the blind lines have to be operated at the same time, using the same test water. Each test period is 21 days.

The drinking water heating devices have to be opened and the heating coils have to be removed after each test. The residual amount of scale in the reservoir has to be sieved with a sieve of 0.5-mm mesh size.

The sieve residue has to be dissolved in diluted nitric acid. Residues on the heating coils and at the internal reservoir walls have to be removed with diluted nitric acid also. From the accumulated solution of the sieve residue and the residues of the heating coils the calcium and magnesium contents must be determined according to DIN standard 38406-3. After another cleaning of the drinking water heating devices with diluted nitric acid and a rinsing with demineralised water takes place, before assembling and installing the drinking water heating device (a mix-up of components is eliminated) for the next series of tests again. The cleaning process has to be done in the same way throughout all drinking water heating devices.

3.5 Blind Trials
(Calibration)

The test set-up has to be tested with blind trials; installing adapters where later the water conditioning devices are used. The blind trials have to be conducted according to the requirements described in 3.1 to 3.4. Each series of tests has to be carried out at least three times.

As a result of each test series there are 4 individual results. The root mean square of the individual results for the series of tests has to be calculated. The individual results cannot differ from the RMS by more than 20% in the test series.

Within these three sequential series of tests the individual results cannot differ by more than 30% of the RMS of all individual results.

If these criteria cannot be met the testing installation has to be adjusted.

3.6 Tests with water conditioning devices

For these tests the water conditioning devices are installed in two of the four test appliances in front of the drinking water heating devices (see figure page 8) according to the manufacturers specifications. The other two test appliances are operated as blind lines.

The testing procedure is carried out according to the requirements described in 3.1 to 3.4.

The tests have to be conducted at least twice. The water conditioning devices and corresponding blind lines have to be alternated.

The results of the analytical evaluation of the individual test series have to be compared to the results of the blind trials that were carried out beforehand. The test results of the blind lines with an adapter have to be in the coherent range of the previously determined series of blind trials (section 3.5). That means, that the individual results from the blind trials cannot differ more than 20% from the root mean square (RMS) and they can not differ more than 30% of the RMS of the overall individual blind trial results.

4 Evaluation

A sufficient effectiveness according to this sheet is fulfilled if the efficiency factor is $f_w > 0.8$. This value has to be met with a confidence interval of 95%. With the amount of required tests a minimum efficiency factor of 0.66 is accepted as an individual test result. The efficiency factor is defined as:

$$F_w = \frac{M[Ca^{2+} + Mg^{2+}]_{untreated} - M[Ca^{2+} + Mg^{2+}]_{treated}}{M[Ca^{2+} + Mg^{2+}]_{untreated}}$$

Where M[] is the amount of substance in mol; $M[]_{untreated}$ are the obtained RMS results of the blind trials and $M[]_{treated}$ are the RMS of the 'active' test lines.

5 **Test Report**

After conducting a test, a test report has to be written including the following information:

a.) Description of the condition of test water

b.) Temperature of the test water in the drinking water heating device

c.) Test time per series of test in days

d.) Amount of water permeated for each test line

e.) Electrical power in kWh for each series of tests

f.) Results of analytical evaluation of the individual test series

g.) Analytical evaluation results of the corresponding blind trials

h.) Evaluation and declaration of determined efficiency factor

i.) Annotations (exceptional features while testing)

Standards and References

DIN 1988-1 Technical Rules for Drinking Water Installations (TRWI); In general; Technical Rule of the DVGW

DIN 1988-2 Technical Rules for Drinking Water Installations (TRWI); Planning and Execution; Components; Apparatus; Material; Technical Rule of the DVGW

DIN 1988-3 Technical Rules for Drinking Water Installations (TRWI); Determination of pipe diameter; Technical Rule of the DVGW

DIN 1988-4 Technical Rules for Drinking Water Installations (TRWI); Protection of Drinking Water; Preservation of Drinking Water Quality; Technical Rule of the DVGW

DIN 1988-5 Technical Rules for Drinking Water Installations (TRWI); Increasing Pressure and Pressure Reduction
Technical Rule of the DVGW

DIN 1988-6 Technical Rules for Drinking Water Installations (TRWI); Fire Extinguishing and Fire Protection Systems; Technical Rule of the DVGW

DIN 1988-7 Technical Rules for Drinking Water Installations (TRWI); Prevention of corroding damages and scaling; Technical Rule of the DVGW

DIN 1988-8 Technical Rules for Drinking Water Installations (TRWI); Operation of Devices; Technical Rule of the DVGW

DIN 38404-10 German Unit processes for the testing of water, wastewater and mud; physical and physical-chemical characteristic substance numbers (group C); calcite saturation of a water (ClO)

DIN 38406-3 German Unit processes for the testing of water, wastewater and mud; cation (group E0); determination of Calcium and Magnesium (E3)

VDI 2035 sheet 1 Prevention of damages in warm water heating devices; scaling in warm water heating devices

Legal regulation: Please refer to BS 3999-16 *and to* BS EN 60379-2-51,